POINTED MOUNTAIN NATURAL GAS PIPELINE

(Construction, Winter 1971-72)

Presented at Arctic Environment Training Course
Petroleum Industry Training Service
Hinton, Alberta
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WESTCOAST TRANSMISSION COMPANY LIMITED
Vancouver, B.C.

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POINTED MOUNTAIN NATURAL GAS PIPELINE

I. INTRODUCTION

In order to tap the Pointed Mountain Gas field, Westcoast designed and constructed 34 miles of 20" pipeline (Map 1) in the winter of 1971-72 commencing at a point in the Pointed Mountain gas field approximately 16.5 miles northwest of Ft. Liard, District of Mackenzie, Northwest Territories, through Yukon Territory to a point on the Yukon - British Columbia border where it connected to the Westcoast Beaver River pipeline.

This 34 mile pipeline became the northern most operational gas pipeline in North America in 1972.

II. GENERAL

Northeastern British Columbia is characterized by the presence of Muskeg and discontinuous perma-frost - which extends into Yukon and Norhtwest Territory. The word muskeg is of Indian (Algonquin) origin and is applied to areas covered more or less with mosses, tussocky sedges, and a growth of scrubby timber. The development, survival, and health of muskeg are governed by climatic factors where the precipitation plus water inflow must be greater than evaporation and run-off. The presence of muskeg requires peat (a product of accumulation of organic matter resulting from incomplete decomposition of plants) and a rate of accumulation greater than decomposition. Muskeg conditions require adjustments in normal engineering design and construction practice.

Winter season construction was selected for this project to take advantage of nature's freezing action to transform all wet areas into a firm working surface. Essentially the process involves a gradual compressing of the surface vegetation, by dozers travelling back and forth which eliminates the insulating characteristics of the material, causing it to freeze when suitable ambient temperature prevails.

Another advantage of winter construction in muskeg areas is the reduction of environmental damage.

III. GEOGRAPHIC TERRAIN

Approximately 77% of the route was along relatively flat ground which was forested with white and black spruce, pine, tamarac, poplar and alder. Most of the rolling terrain was north of La Bache River. About 11% of the route was covered by swamp and muskeg and about 12% with immature timber. The route crosses more than thirty water courses, the largest two being the La Bache and Kotaneelee Rivers, both tributaries to the Liard. Because of level terrain drainage was generally incomplete.

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Perma-frost was observed in four sections of the pipeline route. Frost was found in swamp areas near Pointed Mountain gas collection point, Mile Post 11.5 about half a mile north of the Kotaneelee River, and in areas between Mile Post 0.2 to Mile Post 1.6 and Mile Post 9.6 to Mile Post 9.9. The ice lenses were 5 to 6 feet deep and were 30 to 50 feet in width.

IV. LOGISTICS

Fort Nelson, located on the Alaska Highway, was used as a staging area as it was serviced by bus, truck, Canadian Pacific Airlines, and British Columbia Railways. Access to construction area was restricted to aircraft to the Beaver River and Pointed Mountain air strips and by winter roads. Ice bridges, constructed from layers of logs flooded with water were installed across Fort Nelson and Liard Rivers. Unseasonably warm weather delayed completion of Liard River ice bridge until mid-January.

A camp complex to serve 400 men, consisting of sleeping quarters, storage, kitchen, and dining units, recreational and first aid units were moved via truck and installed on a cleared 10 acre plot of land serviced with water, sewer and electricity. Workshops, water storage, electric generator, septic lagoons, parking areas with electrical plug-ins, warehouse and office sites were set up making a 10 acre area take on an appearance of a "small community". Communication was by Citizens' Band Radio and Canadian National Telecommunications. All food, pipe, construction material and construction equipment were trucked in over the 120 miles of winter road. Twice daily chartered fixed wing aircraft ferried personnel, mail and emergent supplies into the camp and back to Fort Nelson.

V. CONSTRUCTION

A. Right-of-Way

Figure 1 shows the width of cleared right-of-way required to build the pipeline which is 33 percent greater than the summer requirement. The additional width is used to pile snow removed from the working area, and the necessity to weld the pipe prior to ditching. The extra expense incurred in procuring, and clearing the additional width still justifies winter construction. In muskeg areas light

tracked muskeg vehicles first traversed the area packing the snow causing the frost to penetrate the ground. This was followed by the removal of the insulating snow cover by dozers. Larger dozers compacted the ground further until the frost penetration reached the required level of approximately 18 to 20 inches. Only the working side was treated in this manner. The snow removed from the working side was bermed over the ditch line to further insulate the ground from frost penetration. Muskeg in natural state cannot support a load of 2 lb/sq. ins., but when frozen to a depth of 18 inches can support loads in excess of 60 lbs. per square inch. Table 1 summarizes the bearing pressures of some pipeline construction equipment.

Timber clearing was accomplished by dozers equipped with sharp cutting blades. The cut timber and brush was piled to burn by dozers equipped with piling rakes.

Grade preparation in the muskeg areas was minimal. However, in rolling terrain large dozers equipped with rippers were used to break up the frozen soil to permit levelling of the right-of-way. Highway type graders continuously graded the right-of-way providing a good travelling surface at all times.

Immediately behind the grading, prior to trenching, the right-of-way was drilled at 200 foot intervals to determine the depth of muskeg. This assessment assisted in determining the amount of weights required to provide the pipeline with negative bouyancy.

B. Pipe Hauling and Stringing

Pipe was hauled from the Fort Nelson rail siding to the construction site by conventional high-boy trucks. The trucks were able to maintain considerable speed because of the relatively smooth travelling surface. "Tow-cats" were required only on very steep hills between stretches of muskeg.

C. Bending

As the welding preceded ditching, the pipe was bent to conform to the contour of the grade. The amount of bend was pre-determined by the bending engineer. Bending was accomplished by feeding the pipe through the bending machine where the pipe was held securely by contoured shoes and progressive short "pulls" along the pipe gave the required degree of bend.

D. Line-Up and Welding of Pipe

After the pipe ends were wire brushed to bright metal and preheated to 300°F, a sideboom tractor carried the pipe ahead to where it was aligned and held in place by an internal, air activated clamp ready for welding. The first bead was placed by three stringer-bead welders welding in downhill direction at a speed of 20" per minute. The complete cycle of alignment and first bead welding took approximately 2 minutes. When the stringer bead was completed, the stringer-bead welders advanced to the next joint, while the 3 hot-pass welders put in the second bead. Final "filling" and "capping" was completed by backend "firing" line welders. In order to prevent weld cracking and formation of objectionable grain structure, succeeding passes were put on before the weld temperature had dropped to 200°F. When 200°F was not maintained, a preheat to 200°F was required.

Welding was not done when the weather conditions were unsatisfactory and would impair the quality of the welds. Welding was not permitted when the ambient temperature fell below -20°F.

The completed weld was circumferentially wrapped with asbestos blanket to slow the cooling, once again to prevent cracks and objectionable grain structure. After the weld cooled it was radiographically inspected for soundness. All used stub ends of welding rod were deposited in a container and carried away to central disposal area each day for pollution control.

E. Ditch Excavation

The ditching operation followed the welding rather than preceding it as it does in summer construction. This procedure enabled the pipe to be lowered-in and backfilled before the backfill froze into unmanageable lumps. The snow berm over the ditch line was cleared off by dozers and the ditch was cut by conventional ditching machines in muskeg and high ground. Backhoes were used in wet areas, and in areas where the surface was required to be broken up by a ripper tractor. The ditch was excavated to a depth to have a minimum of 30" cover over the pipe. In perma-frost areas, the ditch was excavated to a depth of 5 to 7 feet to remove all ice lenses.

Ditching was most difficult and slow in areas where small boulders of grapefruit size and larger were interspersed in clay. The rocks were locked similar to rocks in concrete.

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F. Coating and Lowering-In

After the pipe was welded into a continuous string, and the weld radiographed, the pipe was thoroughly cleaned of all rust, scale, ice and snow by a line travelling cleaning machine employing counter rotating cupped steel brushes. This was followed by a "train" of three direct-fired propane heaters to heat the pipe to temperatures not greater than 100°F to dry the pipe. The priming operations followed immediately, covering the entire surface with thin, even coat of priming material. The wrapping operation followed immediately behind the priming operation. The pipe was then simultaneously spiral wrapped with polyethylene tape and felt ovenwrap, using a power driven line travelling application machine with spool brake adjusted to provide the manufacturers' recommended tension on the polyethylene tape. Holiday detectors, operating at 7,500 volts, were used to detect voids in coating. Pipe was cradled directly into ditch from the wrapping machine by sideboom tractors.

Because the travelling surface was firm with frost and level with continuous grading, the coating and lowering-in operations were very easy.

G. Installation of Weights

In areas of perma-frost, muskeg, ponded water, creeks and rivers, etc. buoyancy problems were solved by weighting the pipeline with cast concrete saddle or bolt-on weights (Figure 2) placed at intervals determined by the specific gravity of muskeg backfill material (Table 2). The weights were manufactured at a central location and hauled to the pipeline in conventional high-boy trucks and stockpiled at the edge of the right-of-way. After lowering-in a crew would set the weights on the pipe.

In muskeg locations where the muskeg was shallow in depth and dry over an impervious bed of clay, the trench was excavated to a depth that buried the entire pipe in the clay, instead of using saddle weights to give the pipeline negative buoyancy.

H. Tie-Ins

Pipe was welded in sections up to a mile in length for ease of installation. After the pipe was lowered-in a "tie-in" crew would weld these sections into a continuous length. These tie-in welds were radiographed, wrapped and backfilled.

I. Backfill

In winter construction it is necessary to backfill the ditch before the frost has a chance to penetrate the excavated ditch material (backfill). Backfilling was accomplished by a power-auger mounted on a dozer. This provided very successful as all lumps and clods were ground to small pieces before covering the pipe.

Rock and clods over 4" in size were not backfilled onto the pipe. When rock was encountered, granular material was hauled in and placed over the pipe to form a protective padding. At each water course crossing, burlap bags filled with granular material were placed around the perimeter of pipe (Figure 4) to grade level to form a dam to prevent the spring run-off water travelling down the ditch line and removing all the backfill. In the wet areas a "mormon board" similar to a drag line (a blade instead of a bucket) was used for backfilling. In this operation the operator casts the blade over the ditch spoil and reels in the spoil over the pipe.

J. River Crossings

The Kotaneelee and La Biche River crossings were selected in a relatively straight stretch of both rivers and where the immediate shore line banks were relatively stable. For scour protection the pipe was buried 12 feet below the river bed. To protect the over-bends and sag bends the slopes were flatter than normal. Swamp weights were used across the flood plain.

River crossings were installed by a special, completely equipped crew. The river bottom was initially sounded to determine its condition. While the dozers were grading the approaches to the river, large backhoes of 1 yd^3 capacity trenched the ditch. Pipe strung out in a continuous chain was welded, x-rayed and externally coated. The pipe was filled with water, and covered over with polyethylene sheet forming an elongated tent. The tent was heated by space heaters. Temperature inside the tent was maintained at +40°F when ambient temperature was -25°F.

The pipe was tested for eight hours to 1.25 times maximum operating pressure prior to installation. After a successful test, bolt-on weights were applied, spaced by wood lagging. Pipe was then cut to manageable sections. After the trench bottom was examined by ultrasonic sounder for depth and obstruction, a pipe section was carried to edge of water and lowered into the ditch by sideboom tractors. The second section was carried to first section, aligned, and welded. These sections were pulled from opposite bank by a winch on dozer. Each section was handled in this manner until total river crossing was installed.

The ditch was backfilled with material originally excavated from the ditch. Burlap bags filled with earth were placed around the perimeter of pipe in ditch to grade level in the river banks and terracing was run across the right-of-way to deflect any surface water flow. (Figure 5)

K. Clean-Up

As soon as backfilling was completed, clean-up of the right-of-way and any additional area was conducted.

(i) All damaged and leaning trees were felled and burned.

(ii) All refuse, brush, stumps and waste material were picked up and burned in a burning shed towed by a dozer.

(iii) The earth on both sides of the pipeline trench, which had been disturbed during construction of the pipeline was graded smooth. Earth which was pushed into trees was brought out to the right-of-way and left smooth.

(iv) All sidehill cuts were sloped to 45° or less to prevent sloughing and injury to wild life.

(v) Water course banks, and steep slopes were terraced to prevent erosion and washing. Figure 5.

L. Final Testing

After completion of backfilling and clean-up, the entire line was air pressure tested to minimum of 1710 psi which was 1.25 times the maximum operating pressure (1365 psi). The line was required to maintain this test pressure for 24 hours. The test pressure, temperature charts, deadweight readings and all pertinent data were subsequently forwarded to the National Energy Board.

M. Environmental and Ecological Requirements

In addition to adhering to standard ecological and environmental requirements the following construction practice was exercised:

(i) Wildlife

Members of construction crew were not allowed to harass or depredate any wildlife species. Personnel were prohibited from carrying firearms on the right-of-way. Garbage was controlled to avoid attracting wildlife.

(ii) Beaver Dams

Before any beaver dams were opened to drain impounded water the local conservation officer of the Fish and Wildlife Branch, Department of Recreation and Conservation, and/or trapline permittee(s) were contacted.

(iii) Archaeological and Paleontological Sites

Dr. J. Millar of the University of Saskatchewan was contacted when construction approached archaeological and paleontological sites at Mile Post 0.0 to Mile Post 0.25, Mile Post 1.45 to Mile Post 2.6 and a marshy area near Milse Post 10.0.

(iv) Streams and Creek Crossings

In muskeg areas all stream and creek crossings traversed by the pipeline were field located and flagged by mosaic chainage so particular care could be taken during construction to ensure that the normal drainage was not been changed. Ditch breakers were installed on the down slope side of the right-of-way o such crossings to ensure that the stream or creek does not flow or channel down the pipe trench line, particularly when the backfill settles due to frost and snow thawing. Ditch plugs were placed on the sides of all stream crossings to prevent the stream from diverting down the ditch line during construction and to prevent ditch water from various sources from entering into the stream or creek and causing siltation conditions.

(a) All construction related activities in or near streams were kept to an absolute minimum.

(b) The width of the cleared stream crossing was the minimum required for construction and safe operation of the access.

(c) Trees were felled away from stream beds and any debris introduced into the water was removed immediately.

(d) No debris of any kind was placed where it will enter the stream at break-up.

(e) Construction roads across streams were composed of gravel and stone. Culverts, and bridges were provided for fish passages to prevent blockage of fish movements. All structures were removed before the spring break-up to avoid blockage.

(f) Fisheries Service was informed before any activity was carried out on La Biche or Kotaneelee River.

(v) Gravel Requirements

Permits were obtained for the excavation and removal of river bed material on all streams. Applications for this permit were forwarded to the Director of Fisheries.

(vi) Right-of-Way Clearing and Timber Removal

Specific attention was given to the clearing of trees located on muskeg conditions. Wherever possible, the trees were cut flush with the terrain surface so as not to remove any unnecessary stumps thus creating opportunities for bog holes in the muskeg surface.

(a) As few trees as possible were removed. Removing additional trees to accommodate future operations was avoided.

(b) Timber was not disposed of by "push-outs".

(c) Log jams in streams located within the right-of-way were removed.

(d) Cross stream or cross ridge skidding of trees was avoided.

(vii) Right-of-Way Debris

All forms of right-of-way debris from daily operations such as paint cans, plastic cans, bottles, coating materials, and containers, welding rods, were collected and disposed of in a central area. Special care was given to the disposal of garbage to prevent the attraction of wildlife. During the course of operations on the right-of-way no fuel, lubricating fluids, insecticides or herbicides were disposed of on the right-of-way.

(viii) Pipeline Accesses

All pipeline accesses or shoeflies were properly restored and left in a stable condition.

(ix) Erosion

At all times steps were taken to limit the amount of erosion material entering various rivers, streams and creeks which would have a detrimental effect on the river biota due to increased siltation conditions.

(x) Slope Diversion

Selective terracing and inverted herringbone diversions (rather than angled slashes) were placed on steep slopes on the pipeline route. Particular attention was made on Kotaneelee south bank where stability was generally very sensitive. (Figure 5)

(xi) Permafrost

All permafrost was excavated from the pipeline trench to ensure that the pipeline was placed on stable material. Weighting of the pipeline in areas of permafrost was adjusted in order to provide a neutral buoyancy condition.

(xii) Fire Control

Sufficient equipment and personnel were available at all times, as required by the Forest Service, to permit the suppression of any accidental fire originating from construction activities.

Field personnel were instructed to report any smoke they could not account for.

(xiii) Right-of-Way Grading Operations

In treed areas the grading material was pushed off the right-of-way after the trees were removed.

(xiv) Establishment of Campsites

The construction camp was constructed for personnel. Necessary permits and authorizations from the provincial health and pollution authorities for the safe disposal of garbage and human waste were obtained.

Sparsely forested area was selected as the camp site.

Caution was exercised to minimize damage to the site. When the camp was disbanded, all trash was cleaned up. Sanitary facilities and the deposition of sewage material was in accordance with B.C. legislation by Section 6 of the Litter Act (1970, c. 22), the Health Act, and Section 5 of the Pollution Control Act, 1967 (1967, c. 34).

(xv) Pollution Control

(a) All debris that resulted during construction was cleaned up.

(b) All markers (flagging, stakes, etc.) were of the type that permitted removal when their use was terminated.

(c) Old campsites, and garbage left in the area from previous field parties were cleaned up.

(d) Garbage was carried back to camp by field personnel daily.

(e) Garbage was placed in closed containers for future disposal.

(f) Combustible material was disposed of at the base camp by high temperature incineration. A Class III type incinerator, American Incineration Institute, was utilized.

(g) Incinerators were located in selected areas to minimize the danger of fire. Spark arrestors were provided on all incinerators.

(h) Accumulating garbage which could attract wild animals was avoided by daily incineration. Residue from the incinerator was disposed of along with non-combustible garbage.

(i) Non-combustible garbage that contained food was incinerated before disposal.

(j) The disposal of garbage was in accordance to Section 4 of the B.C. Litter Act (1970, c. 22).

Permits were received in compliance with Section 5 of the B.C. Pollution Control Act, 1967 (1967, c. 34) and disposal facilities were in accordance with the B.C. Health Act and regulations (1970, c. 22, S.4; 1972, c. 33, S.5).

Disposal of sewage was in compliance with all existing legislation, particularly Section 5 of the Litter Act (1970, c. 22), Section 5 of the Pollution Control Act, 1967, Section 2.139 of the Sanitation Regulations and the B.C. Pollution Board's Minimum Requirements for Discharge of Domestic Wastewaters to Surface Waters.

(xvi) Fuel Handling

(a) Fuel storage sites were selected and preventative measures were taken to prevent pollution of any stream and to minimize lateral flow of spilled fuel on the land surface.

(b) The storage area was lower than the camp so that any spill and/or fire will not endanger the camp facilities.

(c) No fuel cache was located within 300 feet of a stream.

(d) When filling the tanks, allowance was made for thermal expansion.

(e) Extreme care was exercised to prevent spillage during refueling and oil changing operations.

(f) Preparations were made that if a spill occurred during the winter, the area would be cleaned up before spring thaw. Mechanical removal of the spilled substance by scraping of shovelling were to be practiced. Snow could be used as a natural absorbent, although straw or sawdust would facilitate future burning.

(g) Disposal of spill material and waste oil would be accomplished by burning as recycling would not be practical.

(h) Revegetation

After completion of pipeline construction reclamation through revegetation was conducted for (i) surface soil stabilization and erosion control of the area traversed by pipeline; (ii) revegetation and reclamation of right-of-way; (iii) research on plant growth potential. Seeds and fertilizer were applied with fixed wing aircraft immediately after construction, at a rate of 80 lbs. of seed per acre to 300 lbs. of fertilizer per acre. This was followed by application of fertilizer for three consecutive years at 200 lbs. per acre.

M. Conclusion

Within three months, 120 miles of winter road, two ice bridges, 400 man camp, and 34 miles of pipeline was constructed. In spite of short daylight hours and low ambient temperature, no particular difficulties were encountered in pipeline construction.

The entire construction was monitored by Governmental Agency of Yukon and Northwest Territory, to observe and report construction practices. Specific agencies monitored (i) right-of-way clearing and clean-up (ii) river crossing trenching, installation and backfill and (iii) native population employment. On site archaeologist followed ditching continuously.

In general the entire project went exceptionally well with excellent co-operation exuded by all who were involved in the project.

Observation of pipeline two years after construction showed that:

(i) Permafrost

Sporadic shallow deposits (averaging 20 inches thick) were confirmed at the northern end of the line. Where deposits occurred on the right-of-way the ditchline usually had experienced minor subsidence. This had stabilized into a steep-walled, shallow, vegetated swale.

Several small areas of the right-of-way had pronounced "sunken ditchline" produced by inadequate refill and berming over permafrost ground. Collections of groundwater in these areas produced a "chain" of shallow pools which changed to a watercourse where any run-off slope was present. Minor gulleying and erosion then occurred. In several very limited areas this action had exposed the pipeline, requiring some remedial work.

(ii) Revegetation

The entire right-of-way had thickly revegetated in several varieties of grasses, notably red fescue, smooth brome, and alfalfa. These and other species were introduced by "artificial" revegetation aided by fertilizers.

Local species of grasses and shrubs had not yet established on the right-of-way because of the present thick cover.

Willows were only sporadically seen.

The relative warmth of the pipeline apparently encouraged a more vigorous vegetation growth over the pipe, producing a richer "tone" of colour.

Unused pipeline crossings, constructed by seismic crews for short-term use only, had generally revegetated. The soil "mantle" on these crossings appeared to come from small shallow burrow sites just beyond the right-of-way; these burrow sites usually remained water-filled.

(iii) Forest Cover

There had been no significant incidence of forest disruption beyond the right-of-way except in the stream re-channelling project at Mile Post 1.0.

Approximately 12 - 15 single trees were downed onto the right-of-way. Trees bordering the right-of-way were exposed to root damage and stronger wind pressures. The fallen trees presented no obstacle to drainage or wildlife.

(iv) Slope Stability

With the notable exception of the Kotaneelee "hill", all slopes exposed on the right-of-way had apparently stabilized and revegetated in grasses. Heavier-rooting shrubs were not usually evident.

Transverse earthen berms seemed to assist stability on steeper slopes by deflecting down-slope drainage, but this was not actively observed. One small eroded section of the right-of-way several miles south of the Kotaneelee hill, had been re-banked and appeared to have restabilized.

On gentle slopes small accumulations of groundwater were seen in sunken ditchline, as chains of shallow pools.

(v) Kotaneelee "Hill"

a) Slope stabilization on this steep hill was understandably retarded by the abrupt natural terracing of the landscape, and the fine sandy tills that lay on the sandstone/shale bedrock of the area.

During construction, the hill crest was lowered and the repose slope reduced in angle; transverse berms were constructed; and the hill was artificially revegetated.

b) Erosion had developed on the hillside, because:

i) Revegetation by grasses was too slow and too shallow;

ii) The fine till on the hillside appear "cohesionless" and easily eroded which in turn disrupted vegetation;

iii) Slope variations on the hill ranged up to and over 50 percent, allowing a significant "head" for drainwaters down the slope to the river floodplain.

c) A fine grass "spray" covered the hill but hardier grasses and deep-rooting shrubs like willow were generally absent. Only a few willows were planted on the steeper section of the slope.

d) The colluvial "fines" from hill erosion since construction had fanned out around the base of the hill on the Kotaneelee River floodplain. This material did not enter, nor approach, the river itself. Lower reaches of the alluvial fan were supporting some willows, suggesting a gradual decrease in the accumulation of eroded material.

(vi) Kotaneelee River Pipeline Crossing

a) This river crossing had exposed and undermined where the river channel had scoured and shifted into its north bank. This shift was apparently instigated by unwieldly accumulations of river debris during a heavy flood.

Approximately 20 feet of pipeline bearing six weights were exposed in the river channel.

b) Subsequent river training programs of placement of shot rock on strategic areas on bank and hauling in of cover material over pipe had stabilized the river.

(vii) Seismic Crossings

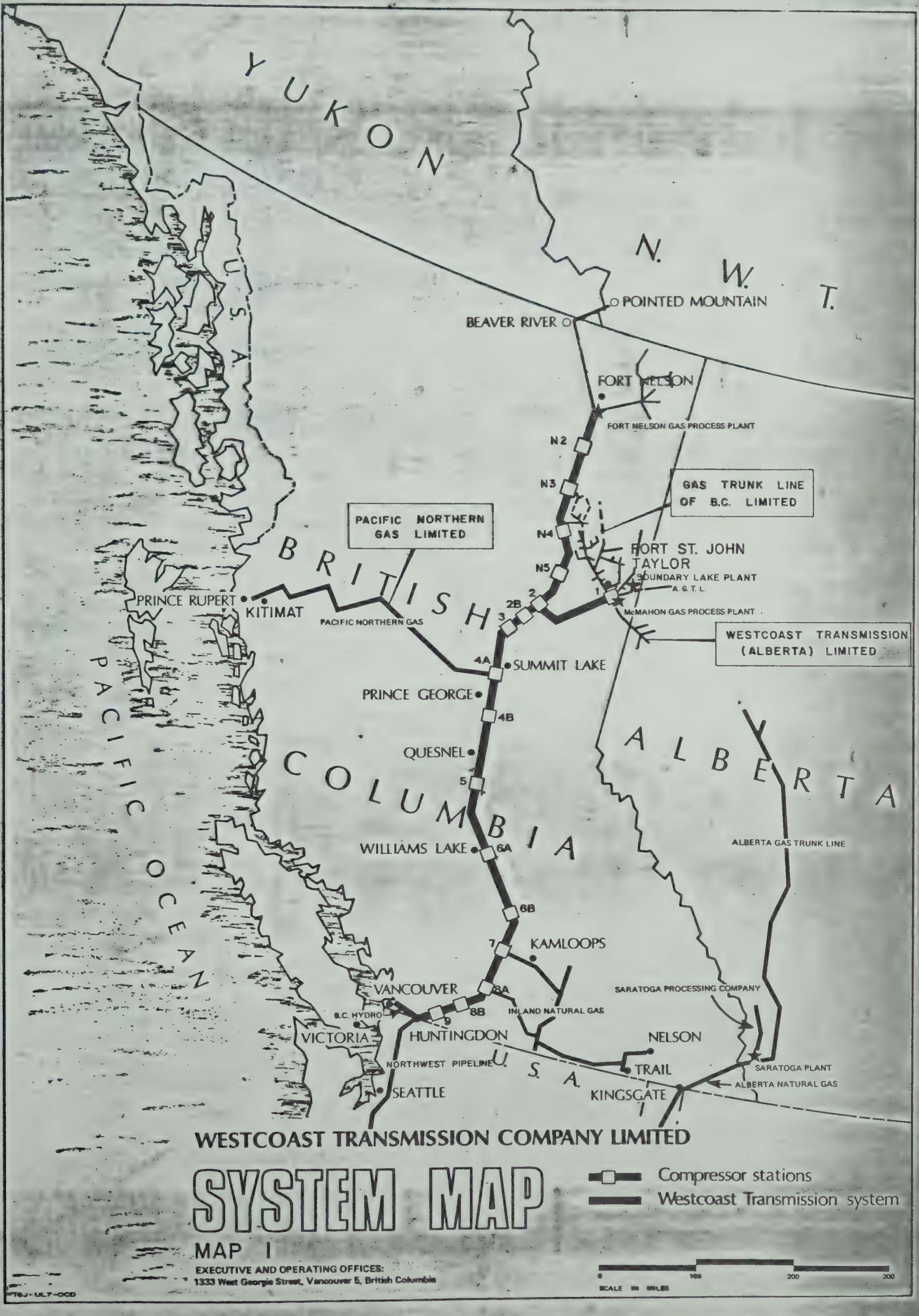
Vehicle crossings over the right-of-way for seismic exploration appeared stable and were not contributing any local damage. One crossing investigated at Mile Post 4.0 was constructed of small logs and packed with earth dug from the edge of the right-of-way. The approximately eight square yard burrow pit had filled with water. Local grasses and shrubs were growing over the crossing structure indicating a lack of use.

(viii) Stream Diversion Channel

A stream diversion channel was built near Mile Post 1.0 to divert a stream "captured" by the cleared right-of-way. The new channel bypassed parts of a large marshy depression near "Northwest Creek", about one mile northwest of Fisherman Lake. Most of the engineered channel ran through a stand of white spruce over permafrost-free ground; the channel appears stable.

The channel was successful in diverting moving water off the right-of-way, but large pondages and chains of ponds in sunken ditchline remained. Vegetation everywhere extends to the edges of these ponds suggesting stability during the period of inspection.

Discontinuous patches of permafrost were found scattered from Mile Post 0.2 to Mile Post 1.6. Water standing on the right-of-way in this area was likely from thermal upset of these permafrost patches combined with the minimal gradient which retarded drainage in this swampy area. With the diversion channel now operating, the water and permafrost situation has now stabilized.



WESTCOAST TRANSMISSION COMPANY LIMITED

SYSTEM MAP

MAP I

EXECUTIVE AND OPERATING OFFICES:
1333 West Georgia Street, Vancouver 5, British Columbia

TABLE 1

EQUIPMENT BEARING PRESSURES

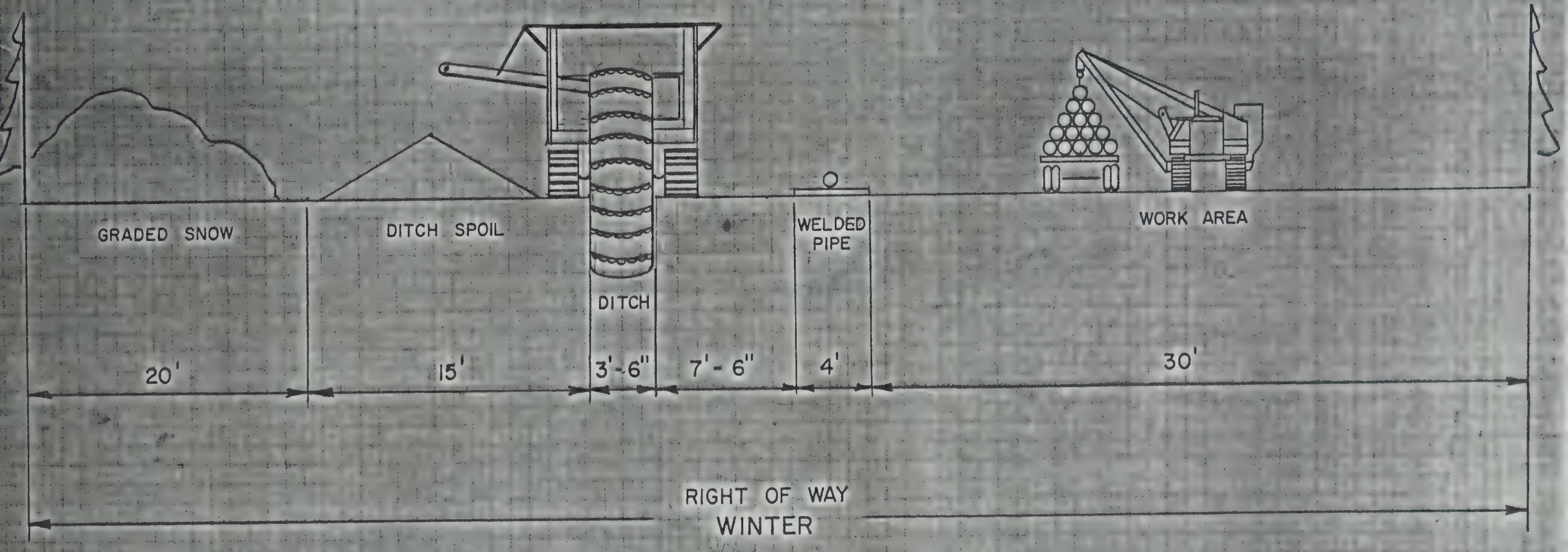
EQUIPMENT TYPE	BEARING PRESSURE (psi)	
Bombardier muskeg vehicle	3.1	
8 ton foremost muskeg vehicle	1.3	
320 ditcher	8.7	
3/4 yard cable backhoe/clam	6.6	
1 yard cable crane	7.6	
D-6 dozer 24 inch tracks	5.3	
D-6 dozer 30 inch tracks	4.2	
D-7 dozer 27 inch tracks	6.9	
D-8 dozer 26 inch tracks bare	9.6	
D-8 dozer 26 inch tracks with ripper	11.2	
D-8 dozer 26 inch tracks with winch	10.9	
D-9 dozer 27 inch tracks std bare ripper	13.5	
571 sideboom	10.5	
572 sideboom	11.1	
583 sideboom	12.4	
594 sideboom	13.7	
955 loader	10.9	
977 loader	10.7	
Model 12 grader	31.0	
Model 16 grader	27.5	
	Front Axle	Rear Axle
3/4 ton crew cab	46.3	58.7
3/4 ton pickup	42.6	54.0
2 ton truck	57.0	70.5
5 ton truck	46.0	75.0
10 ton truck	46.0	63.5
Tractor trailer (highway)		
Tractor	52.0	58.0
Low boy trailer		45.0
Oilfield tractor trailer c/w D-9 load		
Tractor	57.0	75.0
Low boy trailer		55.0

TABLE 2

SADDLE & RIVER WEIGHT SPACING

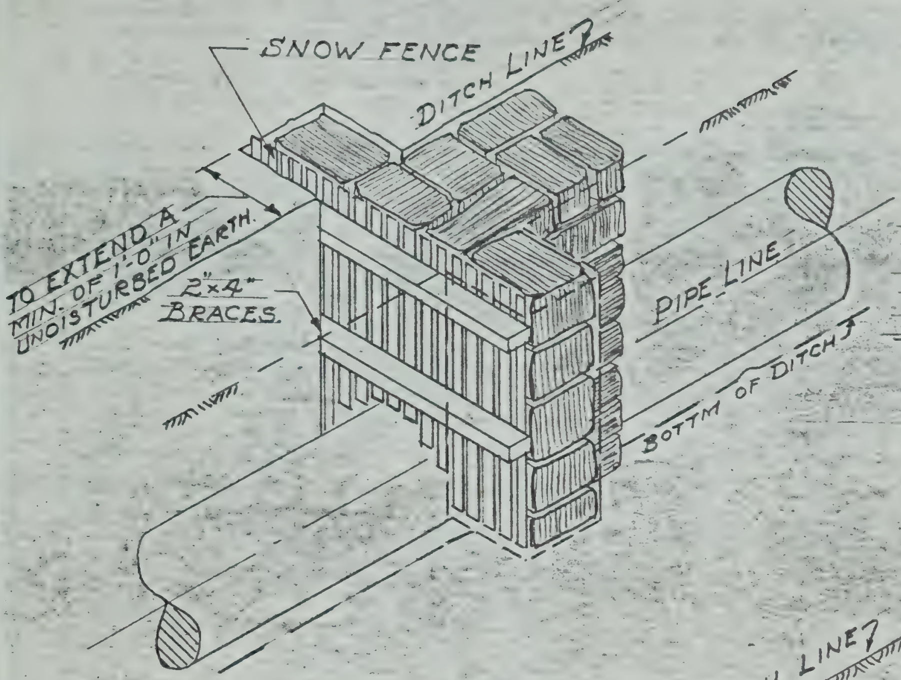
WEIGHT OF EACH SWAMP WEIGHT = 4000 LB
WEIGHT OF ONE CU.FT. OF SWAMP WEIGHT = 145 LB/CU. FT.
VOLUME OF SWAMP WEIGHT = 27.59 CU. FT.
NEGATIVE BUOYANCY REQUIRED = 10 %

MUSKEG SPECIFIC GRAVITY	CENTER/CENTER SPACING OF WEIGHT (FT.) for 20" x .365" W.T.	 20" x .438" W.T.
1.00	34.75	46.33
1.05	30.01	38.69
1.10	26.15	32.83
1.15	22.94	28.19
1.20	20.24	24.44
1.25	17.93	21.33
1.30	15.94	18.72
1.35	14.20	16.49
1.40	12.66	14.57
1.45	11.30	12.89
1.50	10.09	11.42

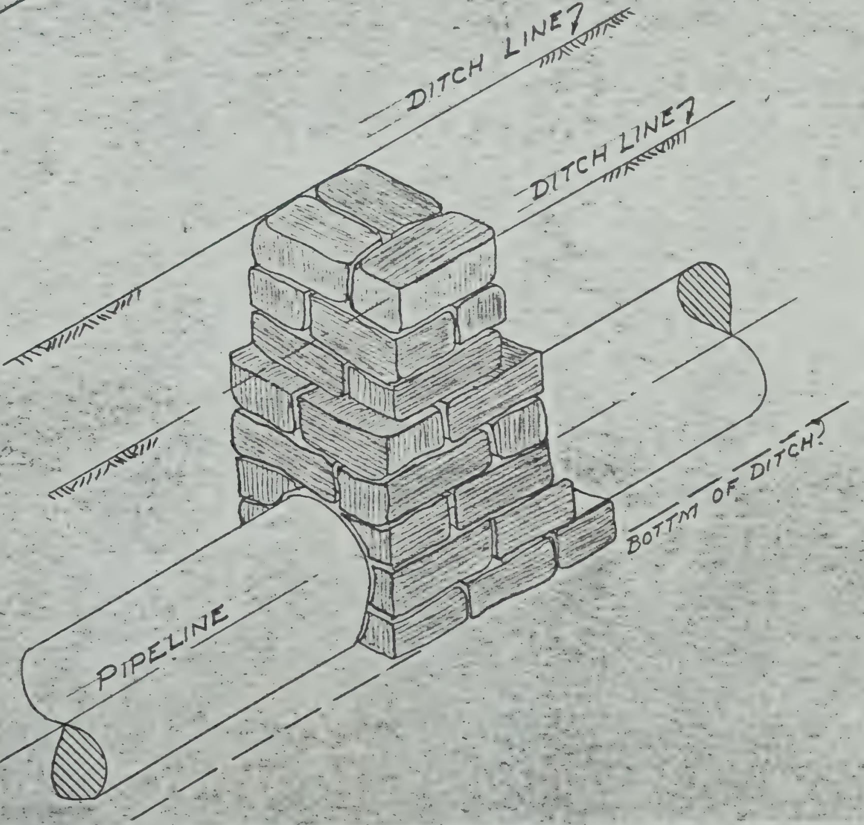


RIGHT·OF·WAY REQUIREMENT 20" O.D. PIPE FOR WINTER CONSTRUCTION

FIGURE 1



COMPLETE BREAKER INSTALLATION



EARTH FILLED SACKS

△3
△2
△1
No. DATE

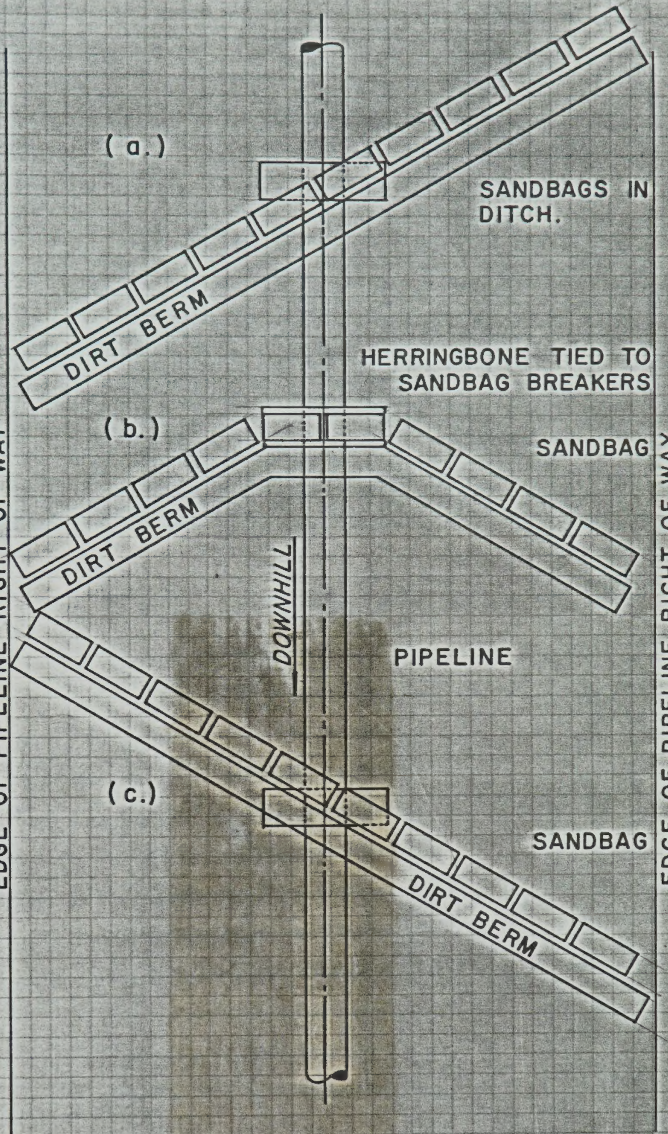
DR. CH'K DR. SUP. ENG. CHIEF ENG.

WESTCOAST TRANSMISSION COMPANY LIMITED

TYPICAL BREAKER INSTALLATION

DR. DATE JOB No. SCALE: NONE
CH'K DR. SUP. DRAWING NO. REV.
ENG. CHIEF ENG. FIG. 4

NOTE : METHOD a, b, OR c SHALL BE DETERMINED BY FIELD ENGINEER, DEPENDING ON HILLSIDE CONTOUR.


(a.)
SANDBAGS IN DITCH.
DIRT BERM
HERRINGBONE TIED TO SANDBAG BREAKERS
(b.)
SANDBAG
DIRT BERM
DOWNHILL
PIPELINE
(c.)
SANDBAG
DIRT BERM
EDGE OF PIPELINE RIGHT OF WAY
EDGE OF PIPELINE RIGHT OF WAY

SCALE
N.T.S.

FIG. 5

WESTCOAST TRANSMISSION
COMPANY LIMITED — ENGINEERING DEPARTMENT — VANCOUVER, B. C.

ENGINEER	DRAWN g. james	TYPICAL HERRINGBONE BREAKER
CHECKED	DRAFTING SUPV'R	
APPROVED MECH. ELEC.	CHIEF ENGINEER	W.O.
DATE OCT. 17, 1977	SCALE NONE	DWG. No. PL - TM - 195
		REV.

Date Due

FB 82			

Pam: 621.644 (*41N)
YAM

45658

YAMAUCHI, Henry M.

AUTHOR

Pointed Mountain natural gas pipeline (construction, winter 1971-72).

TITLE

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